

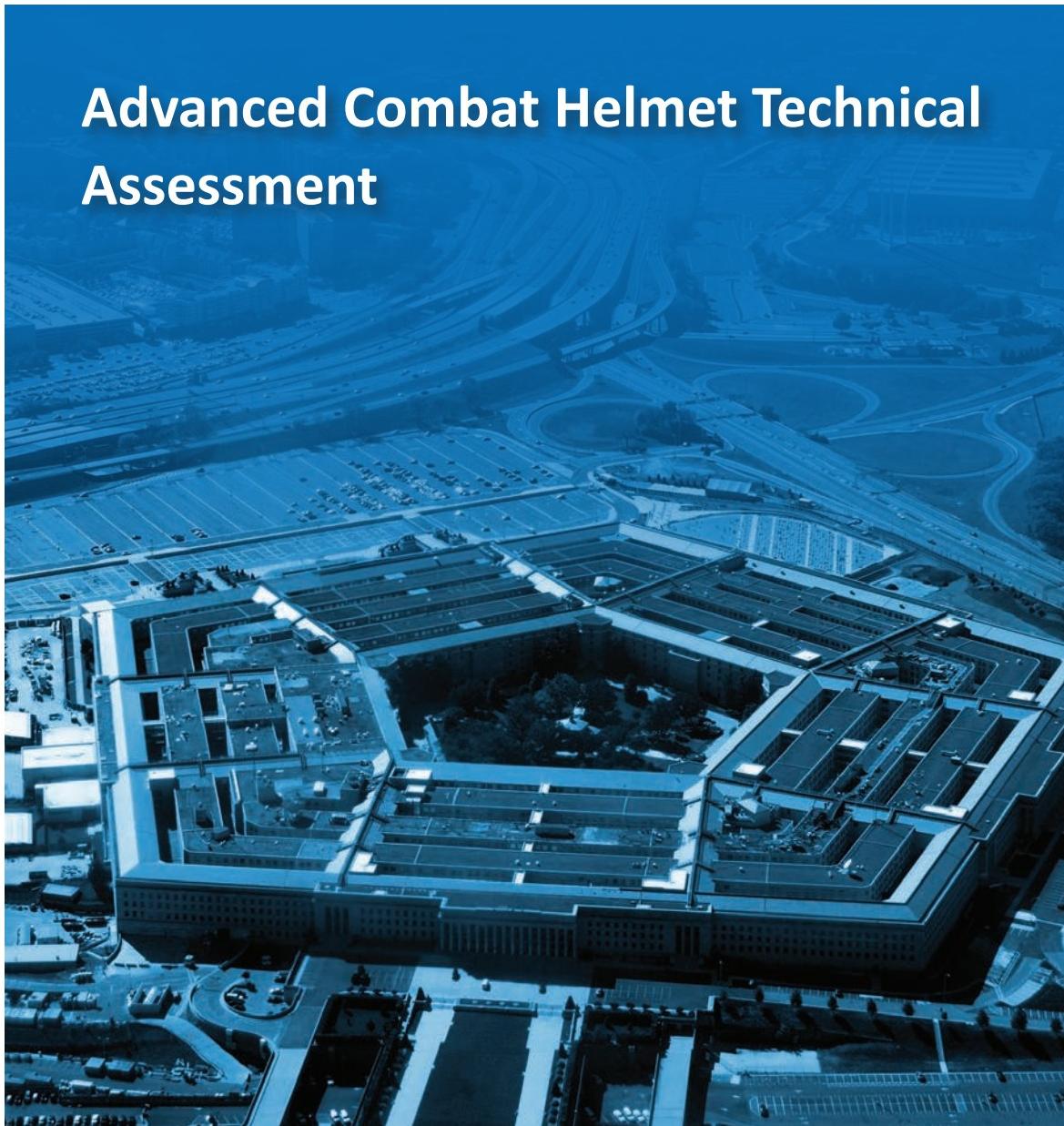


# INSPECTOR GENERAL

*Department of Defense*

MAY 29, 2013

## **Advanced Combat Helmet Technical Assessment**



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# Results in Brief

## Advanced Combat Helmet Technical Assessment

May 29, 2013

### Objective

Our objective was to assess the methods and technical rationale in developing the Advanced Combat Helmet (ACH) testing protocols issued by the Office of the Director, Operational Test and Evaluation (DOT&E) to determine whether the test protocols are appropriate for the ACH. Specifically, our assessment focused on the First Article Testing (FAT) Resistance to Penetration (RTP) requirement of at least 90 percent Probability of no Penetration ( $P(nP)$ ) with 90 percent Confidence Level, commonly termed the "90/90 standard," and the Lot Acceptance Testing (LAT) RTP requirement of 4 percent Acceptable Quality Level (AQL). Lastly, we assessed the participation of various stakeholders and industry experts such as active ACH manufacturers and test facilities.

### Findings

After reviewing the methods and technical rationale in developing the helmet RTP requirements, we found the following.

- A. The DOT&E test protocol for the ACH adopts a statistically principled approach and represents an improvement from the legacy test protocol with regard to increased sample size. However, future protocol revisions necessitate further refinement by anchoring the RTP requirements to helmet specific empirical data such as manufacturing capabilities and test performance.
- B. The DOT&E LAT protocol is an improvement from the legacy LAT and adopts a widely established and industrially accepted American National Standards Institute (ANSI Z1.4-2008, Sampling

### Findings Continued

Procedures and Tables for Inspection by Attributes). In selecting the LAT RTP requirement of 4 percent AQL, DOT&E considered the government risk of accepting underperforming helmets, manufacturer risk of failing LAT with acceptable helmets, and historical LAT data. However, DOT&E did not consider selecting an AQL that was based on the safety criticality of the helmet.

- C. In accordance with authorizing statutes, DOT&E has the authority to establish test standards for personnel protective equipment such as the ACH. However, despite the significance and broad impact of these protocols, DOT&E did not explicitly consult with heads of the Military Departments to provide them an opportunity to comment on new or changed test protocols and did not adequately document the adjudication of inputs provided by program offices and subject matter experts in the staffing process. The program office also did not solicit comments on the helmet test protocols with the helmet vendors and Defense Contract Management Agency (DCMA).
- D. The FAT RTP acceptance was based on an aggregate of all test outcomes under varying conditions to achieve 90/90, or 17 penetrations out of 240 shots. This could result in passing FAT, despite test results showing clusters of failures for a unique helmet size or in a particular test environment.

### Recommendations

During the course of this assessment, DOT&E and the Army's Program Executive Office (PEO) Soldier were very responsive and have already committed to address most of the findings identified. Our recommendations pertaining to the findings are detailed on the next page.



# Results in Brief Continued

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## *Advanced Combat Helmet Technical Assessment*

### ***Recommendations Continued***

#### ***Recommendation for Finding A. Origin of Resistance to Penetration Requirements***

We recommend that DOT&E and PEO Soldier fully characterize the performance of all helmet designs included in the combat helmet test protocols. Performance characterization should consider threat, historical test data, prototype test data, and manufacturing capabilities. Based on helmet performance characterizations, DOT&E and PEO Soldier should determine if modification to the FAT and LAT protocols are appropriate.

#### ***Recommendation for Finding B. Acceptable Quality Level Based on Safety Criticality***

We recommend that in addition to considerations made to Government risk, manufacturer risk, and historical LAT data, DOT&E should also consider the safety criticality of the helmet in establishing the AQL requirement for LAT RTP in future protocol revisions.

#### ***Recommendation for Finding C. Coordination of Helmet Test Protocols***

Due to the significance and broad impact of these protocols, we recommend that DOT&E ensure the affected organizations, including heads of the Military Departments, are consulted in developing the protocols and have an opportunity to provide input on new or changed test protocols. DOT&E should also ensure that inputs received are documented and adjudicated.

We recommend that PEO Soldier solicit input from helmet vendors and DCMA on new or changed test protocols. PEO Soldier should also ensure that inputs received are documented and adjudicated.

We recommend that DOT&E include an explicit statement in future protocol revisions that allows program managers to modify the test protocols, provided that program managers submit a well-justified request for approval.

#### ***Recommendation for Finding D. Evaluation of Aggregate Test Results***

We recommend that DOT&E and PEO Soldier describe the method of identifying and addressing statistically significant differences in performance due to environmental conditions, helmet sizes, shot locations, and different vendor designs for all FAT results under the DOT&E helmet test protocol.

We recommend that PEO Soldier and Defense Logistics Agency (DLA) consider the contractual implications of not fielding an ACH design that passes FAT yet shows significant clusters of inadequate performance.

### **Overall DOT&E and PEO Soldier Comment**

DOT&E and Program Executive Office (PEO) Soldier have reviewed the referenced report and agree with the findings and recommendations.

### **Overall DoD OIG Response**

DOT&E and PEO Soldier's comments were fully responsive. We reviewed their response and have additional points for consideration. However, no additional comments are required.



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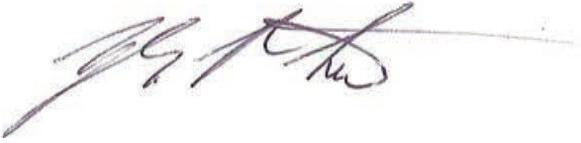
May 29, 2013

**MEMORANDUM FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION  
U.S. ARMY PROGRAM EXECUTIVE OFFICE, SOLDIER**

**SUBJECT:** The Advanced Combat Helmet (ACH) Technical Assessment (Project No.D2012-DT0TAD-0007.000)

This final report is provided for information and use. On July 13, 2012, the DoD Office of Inspector General (OIG) announced the ACH Technical Assessment in response to a request from Representative Louise M. Slaughter to review the current testing protocols for ACHs. During the assessment, we found that the helmet test protocols are an improvement from legacy protocols. The first article test protocol adopts a statistically principled approach and the lot acceptance test protocol adopts a widely established and industrially accepted sampling procedure. We provided our findings and recommendations for review and determined that your comments were fully responsive.

We appreciate the courtesies extended to the staff. For additional information on this report, please contact Al Dopita at (703) 699-0220 (DSN 664-0220), or [alois.dopita@dodig.mil](mailto:alois.dopita@dodig.mil).



Randolph Stone  
Deputy Inspector General  
Policy and Oversight

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# Introduction

## Objective

This report is in response to a request from Representative Louise M. Slaughter, which can be found in Appendix B. Representative Slaughter requested on June 26, 2012, that the DoD Office of Inspector General (OIG) review the current testing protocols for Advanced Combat Helmets (ACHs), expressing concerns that:

... recent modification to the standard for ballistic testing for ACHs would allow up to 17 penetrations out of 240 test shots. The result of that standard is a 90% probability of no perforation [penetration] with 90% confidence during first article testing. I am concerned that a standard that allows 17 penetrations puts contractors above the need to produce effective and consistent equipment for the men and women of the military.

While procurement standards have improved in recent years, the current standard poses an unacceptably high risk for equipment intended to protect American lives.

Our objective was to assess methods and technical rationale in developing ACH testing protocols issued by the Office of the Director, Operational Test and Evaluation (DOT&E)<sup>1</sup> to determine whether the test requirements are appropriate for the ACH. Specifically, our assessment focused on First Article Testing (FAT) Resistance to Penetration (RTP) requirement of least 90 percent Probability of no Penetration ( $P(nP)$ ) with 90 percent Confidence Level, commonly termed the “90/90 standard,” and Lot Acceptance Testing (LAT) RTP requirement of 4 percent Acceptable Quality Level (AQL). We assessed the participation of various stakeholders and industry experts, including the DOT&E-mandated test facility and ACH manufacturers. We also evaluated the RTP requirements of the legacy ACH FAT and LAT protocols for comparison. (See Appendix A for discussion of our scope and methodology)

<sup>1</sup> Protocols reviewed were:

- “Military Combat Helmet Standard for Ballistic Testing” issued December 7, 2010
- “Military Combat Helmet Standard for Ballistic Testing” issued September 20, 2011
- “Military Combat Helmet Standard for Ballistic Lot Acceptance Testing” issued January 19, 2012
- “Military Combat Helmet Standard for Ballistic Lot Acceptance Testing” issued May 4, 2012

## Background

### Advanced Combat Helmet

The ACH replaces the Personnel Armor System, Ground Troops (PASGT) Helmet for general use by the U.S. Army. The ACH consists of a finished ballistic protective shell, pad suspension system, a retention system (chin strap/napo strap), cover, and eyewear retention strap. The Acquisition Decision Memorandum (ADM) for the ACH was approved on January 8, 2003, with the goal of modifying the PASGT Helmet outer shell geometry, while at the same time applying material technology advancements to reduce the weight and maintain protection against fragmentation of 9mm small arms munitions.

*Figure 1. Combat Helmet Design Evolution*

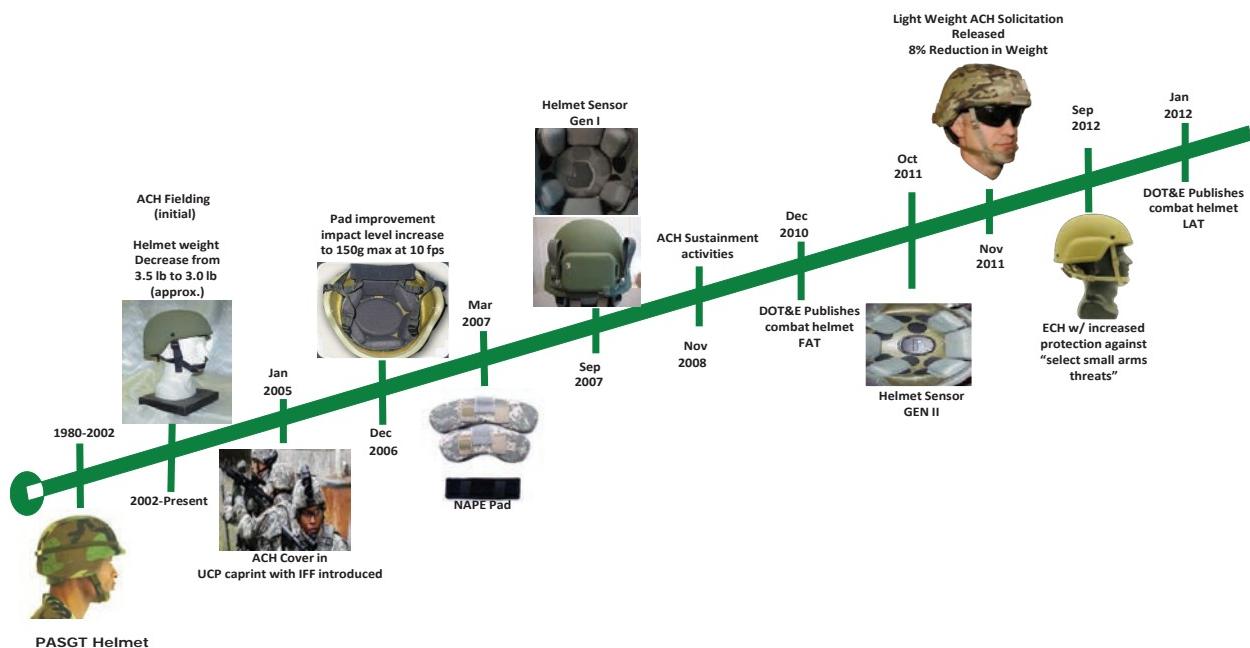


Figure 1 provides the evolution of combat helmet design and depicts that initial fielding of the ACH began in 2002. Pad improvements occurred in 2006 and 2007. For example, helmet sensors were developed to detect when a helmet has been subjected to a force strong enough to cause brain injury. More recent efforts are underway to reduce the weight of the ACH and develop a helmet with increased protection against select small arms threats.

Program Executive Office (PEO) Soldier, Product Manager/Soldier Protective Equipment (PM/SPE), is the program office responsible for developing and managing the ACH

product specification. PEO Soldier was responsible for the initial fielding of the ACH using equipping funds beginning in August 2005. Sustainment activities began in November 2008 when Defense Logistics Agency Troop Support (DLA TS) became responsible for ACH procurements. However, PEO Soldier retains responsibility for life cycle management of the system, including the product description and technical specifications. PEO Solider also assists DLA TS in evaluating vendors for sustainment procurements.

There are currently two active ACH sustainment bridge contracts to procure ACHs with design specifications detailed in Contract Purchase Description “CO/PD-05-04,” October 30, 2007 (most recently updated on March 24, 2009). The first is a bridge contract to Gentex Corporation (contract number SPM1C1-12-C0016) and the second to Mine Safety Appliances (contract number SPM1C1-12-C0019), each for 90,000 helmets (180,000 helmets total). A third contract solicitation to produce a lightweight ACH (8 percent weight reduction), has yet to be awarded. The bridge contracts follow the ballistic testing requirements of the legacy test protocol, and the lightweight ACH solicitation will follow ballistic testing requirements of the DOT&E test protocols. Table 1 lists all active ACH procurements.

*Table 1. ACH Contracts and Solicitation*

Procurement	Vendor	Contract Number	Award Date	Ballistic Testing
ACH Production Bridge Contract	Gentex Corporation	SPM1C1-12-C-0016	May 7, 2012	Legacy Test Protocol (CO/PD-05-04)
ACH Production Bridge Contract	Mine Safety Appliances <sup>2</sup>	SPM1C1-12-C-0019	June 14, 2012	Legacy Test Protocol (CO/PD-05-04)
Lightweight ACH	TBD	TBD	TBD	Incorporated DOT&E Protocol (AR/PD 10-02 Rev A with Change 4)

## **ACH RTP Performance Requirements**

The ACH is designed to provide ballistic protection from fragments as well as 9mm projectiles. The helmet shell, including any hardware exposed on the outside of the shell, is designed to be resistant to a 9mm Full Metal Jacketed Round Nose (FMJ RN) Remington bullet penetration with a nominal mass of 124 grains. The 9mm FMJ RN ballistic test is an industry standard adopted from the National Institute of Justice (NIJ) Standard 0101.06, “Ballistic Resistance of Body Armor.” It was also derived from the Operational Requirements Document (ORD) for the Land Warrior, which outlines the requirements

<sup>2</sup> The division of Mine Safety Appliances that produced ACHs was purchased by Revision Military Limited in June 2012.

and operational capability needs of an integrated soldier protection and equipment system. The ORD states that the greatest threat to the land warrior is fragmentation and the second greatest threat is bullets. For the ACH, the 9mm FMJ RN test does not only represent a capability to be resistant against bullets but also larger sized fragments.

The ACH is not designed to provide ballistic protection from threats more lethal (for example, higher velocity, or larger mass) than a 9mm FMJ RN. Field data indicate that the ACH performs well against its intended threats, but is penetrable from rifle threats that are most commonly seen in theater. A new product called the Enhanced Combat Helmet (ECH) is currently under design and development to defeat threats more lethal than a 9mm FMJ RN.

### ***ACH RTP Ballistic Testing***

According to contract requirements, the ACH is required to undergo FAT and LAT. FAT is conducted on a specified sample size and determines whether the proposed product and manufacturing design meets testing requirements prior to proceeding to production. LAT determines whether a produced lot meets testing requirements prior to delivery. Both FAT and LAT for the ACH consists of non-ballistic and ballistic test and inspection requirements. This report focuses on the RTP ballistic testing requirements.

ACH RTP ballistic testing for the helmet consists of firing 9mm projectiles at a defined velocity and distance from the helmet to demonstrate a required level of penetration protection. RTP test requirements include the acceptable number of complete 9mm FMJ RN penetrations<sup>3</sup> for each sample size.

### ***DOT&E Role in Combat Helmet Testing***

In 2007, both the House Armed Services Committee and Senate Armed Services Committee wrote to the Secretary of Defense expressing their desire and support for DOT&E involvement in body armor testing. The United States Congress amended Public Law 110-417, "Duncan Hunter National Defense Authorization Act for Fiscal Year 2009," to expand the Secretary of Defense's authority to designate programs for realistic survivability testing. The Secretary of Defense subsequently authorized DOT&E's involvement in body armor testing and updated DoD Directive 5141.02, "Director of Operational Test and Evaluation," to state that DOT&E shall prescribe policies and procedures for the conduct of

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<sup>3</sup> According to AR/PD 10-02 Rev A with Change 4, May 8, 2012, "Purchase Description Helmet, Advanced Combat (ACH)," complete penetration shall be defined as complete perforation of the shell by the projectile or fragment of the projectile as evidenced by the presence of that projectile, projectile fragment, or spall (fragments of the test helmet being impacted, excluding fibrous material, paint, and epoxy particles emitted from the helmet surface) in the clay, or by a hole which passes thru the shell.

Live Fire Test and Evaluation (LFT&E). LFT&E includes Personnel Protective Equipment (PPE) testing such as hard body armor, soft body armor, and helmets.

In response to a January 2009 DoD OIG Report No. D-2009-047, “DoD Testing Requirements for Body Armor,” DOT&E published the hard body armor FAT protocol on April 27, 2010, and the LAT protocol on July 2, 2010. On December 7, 2010, DOT&E published the Military Combat Helmet Standard for Ballistic Testing FAT applicable to all DoD combat helmet acquisition programs, including the ACH. The DOT&E FAT protocol states that combat helmets must meet a set of statistically based FAT to qualify a design/manufacturing process for full-rate production. The FAT protocol was updated on September 2, 2011, to include both aramid-based helmets, such as the ACH and Lightweight Helmet (LWH), and ultra-high molecular polyethylene-based helmets, such as the ECH, designed to defeat threats more lethal than a 9mm FMJ RN. On January 19, 2012, DOT&E released the Military Combat Helmet Standard for Ballistic Lot Acceptance Testing protocol, detailing test requirements that must be met prior to accepting a production lot from a vendor. It was updated on May 4, 2012, with revisions to the RTP test matrix for aramid-based helmets.

### **FAT RTP Requirements**

The FAT RTP legacy requirements used by ACH bridge contracts were established in the Contract Purchase Description “CO/PD-05-04,” October 30, 2007 (most recently updated on March 24, 2009). CO/PD-05-04 requires a sample size of four helmets tested under different environmental conditions and shot five times. Under CO/PD-05-04, one penetration of the total 20 shots will result in a failed FAT. The sample size and number of allowable penetrations are not derived from a known statistical model.

In contrast to the legacy FAT RTP requirement, the DOT&E FAT RTP requirement is statistically based. The FAT RTP requirement increases the sample size to 48 helmets at 5 shots per helmet, totaling 240 shots based on an established “90/90 standard.”<sup>4</sup> An increase in sample size increases the statistical confidence of the testing result.

The Clopper-Pearson method is used to calculate the allowable number of penetrations out of a given sample size. When applied against the required parameters (90/90 and 240 shots), the Clopper-Pearson method yields 17 allowable penetrations. A more detailed explanation of the Clopper-Pearson method can be found in Appendix C. Table 2 shows a comparison of the legacy FAT RTP and DOT&E FAT RTP.

<sup>4</sup> The commonly termed “90/90 standard” for First Article Testing (FAT) Resistance to Penetration (RTP) requirement is at least 90% Probability of no Penetration ( $P(nP)$ ) with 90% Confidence Level.

*Table 2. Comparison of FAT RTP Protocols*

<b>9 mm RTP shell</b>	<b>Ambient 70° F</b>	<b>Hot 160° F</b>	<b>Cold -60° F</b>	<b>Immerse in Seawater, then test at 70° F</b>	<b>Totals</b>	<b># Allowable Penetrations Accept/ Reject</b>
Legacy test protocol sample size	5 shots 1 helmet	5 shots 1 helmet	5 shots 1 helmet	5 shots 1 helmet	20 shots 4 helmets	0/1
DOT&E test protocol sample size	60 shots 12 helmets	60 shots 12 helmets	60 shots 12 helmets	60 shots 12 helmets	240 shots 48 helmets	17/18

## **LAT RTP Requirements**

The legacy LAT RTP requirement used by ACH bridge contracts were also established in CO/PD-05-04. CO/PD-05-04 defines the sample size per lot size delivered in Table 3, and specifies that one 9mm penetration will result in a failed lot regardless of the lot size.

*Table 3. Legacy LAT RTP*

<b>9 mm RTP shell</b>	<b>Lot Size</b>	<b>Sample Size</b>	<b>Accept</b>	<b>Reject</b>
	4-150	5 shots 1 helmet	0	1
	151-1,200	5 shots 1 helmet	0	1
	1,201-3,200	10 shots 2 helmets	0	1

In contrast to the legacy LAT, the DOT&E LAT RTP requirement is 4 percent AQL.<sup>5</sup> The sampling plan to determine the accept/reject criteria is based on the American National Standards Institute (ANSI) American Society for Quality (ASQ) Z1.4-2008 with a special inspection level S-3. These translate to the sample size and accept/reject criteria in Table 4.

*Table 4. DOT&E LAT RTP*

<b>9 mm RTP shell</b>	<b>Lot Size</b>	<b>Sample Size</b>	<b>Accept</b>	<b>Reject</b>
	91-150	25 shots 5 helmets	0	1
	151-500	40 shots 8 helmets	1	2
	501-1,200	65 shots 13 helmets	1	2
	1,200+	65 shots 13 helmets	1	2

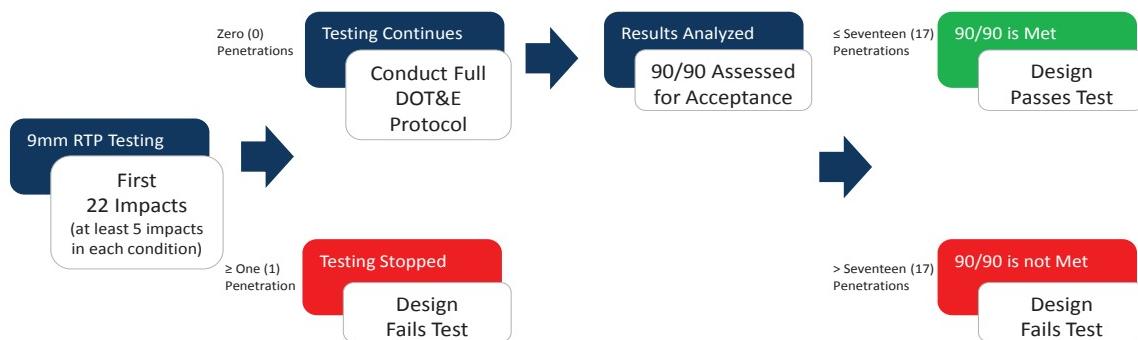
<sup>5</sup> According to ANSI/ASQ Z1.4-2008, AQL is the quality level that is the worst tolerable process average when a continuing series of lots is submitted for acceptance sampling.

## Implementation of DOT&E Helmet Test Protocols

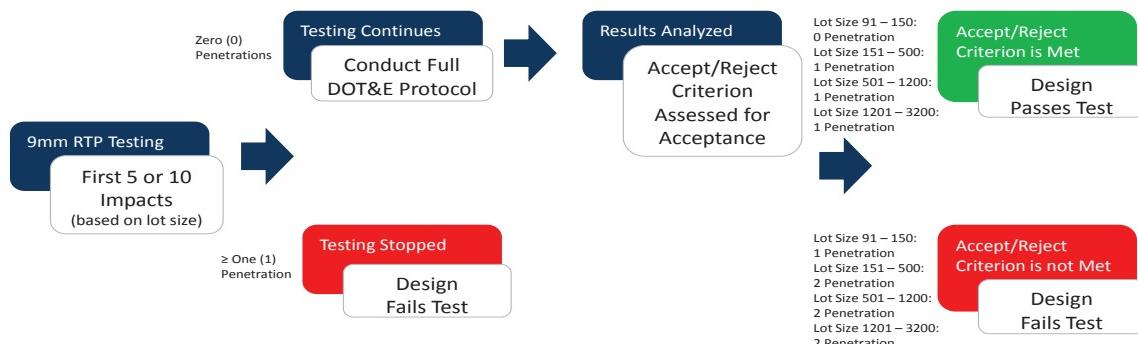
Because the DOT&E FAT and LAT protocols are not intended to be applied against already qualified designs, the ACH bridge contracts SPM1C1-12-C-0016 and SPM1C1-12-C0019 were precluded from implementing the DOT&E test protocol requirements. However, PEO Soldier was required to incorporate the DOT&E test protocols in the lightweight ACH specification. The incorporated test protocols are detailed in the Contract Purchase Description, "AR/PD 10-02 Rev A with Change 4," May 8, 2012.

In "AR/PD 10-02 Rev A with Change 4," PEO Soldier established a "hybrid FAT" and a "hybrid LAT" in an effort to combine the legacy test protocols with the DOT&E test protocols. The hybrid FAT requires that the first 22 shots yield zero penetrations prior to conducting the full DOT&E FAT protocol.<sup>6</sup> The hybrid LAT requires that the first 5 or 10 shots (depending on lot size) yield zero penetrations prior to conducting the full DOT&E LAT protocol. According to PEO Soldier, the hybrid test strategy ensures that the pedigree of the past helmet's testing requirements continues into the lightweight ACH procurement. Both RTP hybrid FAT RTP and LAT RTP summaries are depicted in Figure 2 and 3.

*Figure 2. Hybrid FAT RTP*



*Figure 3. Hybrid LAT RTP*



<sup>6</sup> The Clopper-Pearson method for binomial confidence intervals requires a minimum sample size of 22.

-David W. Webb, Army Research Laboratory, A Comparison of Various Methods Used to Determine the Sample Size Requirements for Meeting a 90/90 Reliability Specification, March 2011, page 28

## Notice of Concern

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We issued a Notice of Concern (NOC) to DOT&E and PEO Soldier on September 12, 2012, stating concerns regarding the implementation of the new helmet protocol in the light-weight ACH solicitation. We recommended that PEO Soldier, DOT&E, and DLA TS work together to ensure that there is no reduction in helmet performance for the new light-weight ACH. DOT&E released a coordinated response with PEO Soldier and DLA TS on October 12, 2012, detailing an initial set of plans to address the NOC.

A memorandum signed by the Deputy Inspector General for Policy and Oversight was issued on December 5, 2012, to document concerns with the helmet protocols and actions that DOT&E and PEO Soldier will take to address those concerns. The memorandum also concluded that the NOC was resolved by DOT&E and PEO Soldier's commitments to address the issues in light of their October 12, 2012, NOC response. A copy of the NOC and the resolution memorandum is in Appendix D.

## Finding A

### Origin of Resistance to Penetration Requirements

The DOT&E test protocol for the ACH adopts a statistically principled approach and represents an improvement from the legacy test protocol with regard to increased sample size. However, future protocol revisions necessitate further refinement by anchoring the RTP requirements to helmet specific empirical data such as manufacturing capabilities and test performance.

## Discussion

### ***Hard Body Armor Test Protocol Studies***

On January 29, 2009, the DoD OIG issued an audit report on DoD Testing Requirements for Body Armor (Report No. D-2009-047, “DoD Testing Requirements for Body Armor”) and recommended that DOT&E develop a test operations procedure for body armor inserts and verify that the procedure is implemented DoD-wide. In response to the DoD OIG report, DOT&E and PEO Soldier collaborated with the Army Test and Evaluation Center (ATEC) to conduct a comprehensive technical assessment of the hard body armor. The technical assessment included ballistic performance evaluation of the Enhanced Small Arms Protective Insert and the X Threat Small Arms Protective Insert against a set of defined threats. DOT&E used the results of the study to establish the body armor test protocols. On April 27, 2010, DOT&E issued the hard body armor FAT protocol, defining FAT RTP 90/90 standard for the first test shot and a 70/90 for the second test shot.

DOT&E also commissioned the National Academies<sup>7</sup> to assess the methodologies used by the U.S. Army for body armor testing and assist in addressing shortcomings that had been reported by the Government Accountability Office and the DoD OIG. The National Academies released the results of their assessment in three phases.<sup>8</sup> The Phase II report addressed DOT&E’s statistically based body armor test protocol and concluded that, “The new DOT&E [hard body armor] protocol meets both key protocol design requirements; it is statistically principled and it provides a minimum DoD-wide body armor test standard.”

<sup>7</sup> The National Academies is composed of the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council. These organizations are private, nonprofit institutions that consist of elected members with distinguished achievement in their respective fields. The National Academies is known for providing objective advice on science, engineering, and health matters. Source: <http://www.nas.edu>

<sup>8</sup> The Phase I report was released on December 30, 2009, Phase II on April 22, 2010, and Phase III on May 21, 2012.

The National Academies recommended that DOT&E implement a statistically based LAT that incorporates aspects of military standard MIL-STD-1916, "DoD Preferred Methods for Acceptance of Product." Subsequently, DOT&E released the body armor LAT protocol on July 2, 2010 with a defined LAT RTP requirement of 4 percent AQL for the first test shot and 15 percent AQL for the second shot. The National Academies did not recommend specific RTP requirements for LAT.

The National Academies also recommended that standards in the protocol should be based on empirical evidence. However, DOT&E stated there is not a comparable body of data that characterizes the performance of the ACH. DOT&E also stated in a memorandum to Representative Slaughter, dated July 13, 2012, that the ACH test protocols were developed to be analogous to the body armor test protocols. Although DOT&E established a helmet test protocol that adopts a statistically principled approach and represents an improvement from the legacy test protocol, the protocol's RTP requirements are not anchored to helmet specific empirical data such as manufacturing capabilities and test performance.

### ***Common RTP Requirements Across PPEs***

It was DOT&E's intent to publish common RTP requirements across all PPEs. According to DOT&E, one of the driving factors for a common standard is public perception. If each individual type of PPE had specific standards, questions may arise as to why one PPE had a lower standard than another. DOT&E also stated that it would be potentially difficult and unmanageable to have individual protocols and designs for each piece of PPE. Furthermore, DOT&E stated that a common standard would provide some level of assurance that all fielded commodities have a minimum level of performance.

DOT&E referenced the DoD OIG audit report on body armor and a series of studies conducted by the National Academies from 2009 to 2012 on body armor. The DoD OIG report states that DoD does not have standardized ballistic testing criteria for body armor inserts. Additionally, the National Academies Phase III report on body armor stated that an encompassing standard for testing would include alignment of body armor and helmet testing procedures and processes. However, neither of the two referenced reports prescribe common parameters such as the FAT RTP 90/90 standard or LAT RTP of 4 percent AQL across all PPEs.

### ***DOT&E Assessment Discussions***

During the course of our assessment, DOT&E and PEO Soldier committed to fully characterizing the performance of the ACH in response to our NOC detailed in Appendix D. DOT&E also indicated that it will also work with the Marine Corps to characterize

the performance of ECH. DOT&E will provide the details of the plans to characterize the helmets to the DoD OIG when the respective plans are approved. DOT&E added that as new designs/technology become available, it will consider the characterization of those designs during developmental testing to assess whether any changes to the test protocol may be appropriate.

DOT&E acknowledged that the performance metrics incorporated in test standards used for PPE should be empirical, based on the data generated by characterization studies conducted on the individual elements of PPE using the appropriate threats. DOT&E stated that deviating from a 90/90 standard could be appropriate, based on the performance revealed by these characterization studies against the specified threats. DOT&E considers the established test standards for hard body armor plates and helmets that reflect a common metric to have elements that are generally applicable to all PPE. Specifically, the standards for PPE testing must be as statistically principled and rigorous.

DOT&E also commissioned the National Academies on August 15, 2012, to determine the adequacy of their military ballistic helmet testing. DOT&E estimates that the National Academies will complete its study by December 2013.

## **Recommendation**

We recommend that DOT&E and PEO Soldier fully characterize the performance of all helmet designs included in the combat helmet test protocols. Performance characterization should consider threat, historical test data, prototype test data, and manufacturing capabilities. Based on helmet performance characterizations, DOT&E and PEO Soldier should determine if modification to the FAT and LAT protocols are appropriate.

## **DOT&E and PEO Soldier Comments**

Characterization on fielded ACH will rely on historical test data since the Army does not intend to buy additional ACH designs. We will conduct additional testing to characterize helmets not currently fielded, such as the Lightweight ACH, the Enhanced Combat Helmet (ECH), the Soldier Protective System Integrated Head Protection System (SPS IHPS). This characterization will be based on a risk assessment that identifies and documents the testing that provides the most important data, since it is unrealistic to scope a characterization effort that includes every desirable test. Based on the characterization data, DOT&E will determine whether FAT and LAT protocols should be modified.

## **DoD OIG Response**

DOT&E and PEO Soldier's comments were fully responsive. In addition to the response, we recommend that the characterization include the Industry's state of the art with regard to controlling manufacturing parameters of the design. No additional comments from DOT&E and PEO Soldier are required.

## Finding B

### Acceptable Quality Level Based on Safety Criticality

The DOT&E LAT protocol is an improvement from the legacy LAT and adopts a widely established and industrially accepted American National Standards Institute (ANSI Z1.4-2008, Sampling Procedures and Tables for Inspection by Attributes). In selecting the LAT RTP requirement of 4 percent AQL, DOT&E considered the government risk of accepting underperforming helmets, manufacturer risk of failing LAT with acceptable helmets, and historical LAT data.<sup>9</sup> However, DOT&E did not consider selecting an AQL that was based on the safety criticality of the helmet.

## Discussion

### *LAT Sampling Plan*

The DOT&E LAT RTP sampling plan was derived from a widely established and industrially accepted ANSI Z1.4 -2008. Sampling plans are particularly applicable to destructive testing<sup>10</sup> such as the 9mm RTP test performed during LAT, when not all helmets in a given lot can be tested. The DOT&E LAT RTP sampling plan is derived from inspection level S-3.<sup>11</sup> ANSI Z1.4-2008 also provides reference to operating characteristic curves to determine the government risk and manufacturer risk at a given AQL.

### *AQL Selection Based on Criticality*

Although the use of a widely established standard represents an improvement from the legacy LAT, DOT&E did not consider selecting an AQL that was based on the safety criticality of the helmet. The Land Warrior Operational Requirements Document (ORD) states that the primary function of the helmet is to protect the Land Warrior's head from fragmentation and bullets and therefore, a helmet is considered a safety critical item and resistance to penetration is considered a critical characteristic.

If a sampling plan is not specified in the contract, the Defense Contract Management Agency (DCMA)<sup>12</sup> will implement DCMA Instruction 226-3, "Critical Safety Items

<sup>9</sup> Government risk is the probability of accepting underperforming helmets while manufacturer risk is the probability of failing LAT with acceptable helmets

<sup>10</sup> Destructive testing is a test that puts the sample object under certain circumstances until it actually fails.  
-H.F. Walker, A.K. Elshennawy, B.C. Gupta, M. McShane-Vaughn, *The Certified Quality Inspection Handbook, Second Edition*, (Milwaukee: American Society for Quality, 2013) page 186.

<sup>11</sup> Per ANSI Z1.4, the inspection level determines the relationship between the lot or batch size and the sample size.

<sup>12</sup> The DCMA was established to perform contract administration for the Department of Defense. DCMA is expected to

(CSIs)" and Instruction 226-4, "Product Examination – Quality Assurance (QA)." DCMA Instruction 226-3 and Instruction 226-14 both state that non-aviation CSI includes personal protective devices and that 0.4 percent AQL is applied for non-aviation CSIs. In addition to the DCMA requirement of 0.4 percent AQL, ACH manufacturers indicated that they recommend, and are currently working to a 0.4 percent AQL. Lastly, *The Certified Quality Process Analyst Handbook* published by the American Society for Quality<sup>13</sup> states that in practice, critical characteristics are commonly inspected to an AQL of 0.4 to 0.65 percent if not 100 percent inspected.

In summary, the DCMA instruction, manufacturer capabilities, and industry standards warrant tighter constraints on components or assemblies used in safety critical applications, thus setting the AQL at a lower level will, over a continuing series of lots, provide the worst tolerable process average appropriate for a safety critical item.

### ***DOT&E Assessment Discussion***

Per DOT&E, the new LAT protocol increases the sample size used for LAT and, in doing so, decreases the risks to the government of accepting underperforming helmets because helmet lots under the previous protocol had a higher chance of passing LAT. DOT&E also considered the risk to the manufacturer of failing LAT if the manufacturer consistently produces helmets with acceptable performance. Per DOT&E, the new and old LAT protocols have similar manufacturer's risk for a helmet. By decreasing government risk while maintaining similar manufacturer's risk, DOT&E stated that the LAT protocol has clearly improved upon the previous LAT. DOT&E has provided the LAT protocol to the National Research Council (NRC) committee on helmet testing and asked the committee to evaluate the construction of the current LAT protocol and to provide its views on how best to relate AQL to FAT performance.

### **Recommendation**

We recommend that in addition to considerations made to Government risk, manufacturer risk, and historical LAT data, DOT&E should also consider the safety criticality of the helmet in establishing the AQL requirement for LAT RTP in future protocol revisions.

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operate in an independent, consistent, transparent, and collaborative manner while performing a wide variety of contract oversight functions. For the ACH program, DCMA is required to prepare surveillance strategies for all ACH contracts to include product audits and inspections. DCMA provide oversight at manufacturing facilities and testing facilities. However, they do not conduct in-process inspections and will no longer need to provide ballistic test surveillance when ACH ballistic testing begins at ATEC.

<sup>13</sup> E.H. Christensen, K.M. Coombes-Betz, M.S. Stein, *The Certified Quality Process Analyst Handbook*, (Milwaukee: American Society for Quality, 2007)

## **DOT&E and PEO Soldier Comments**

DOT&E will consider helmet safety criticality as an additional consideration in establishing the AQL requirement for LAT RTP during the next protocol revision. The next protocol revision will consider recommendations from the on-going National Academies review of helmet test protocols. This study should be complete by December 2013.

## **DoD OIG Response**

DOT&E and PEO Soldier's comments were fully responsive, and no additional comments are required.

## Finding C

### Coordination of Helmet Test Protocols

In accordance with authorizing statutes, DOT&E has the authority to establish test standards for personnel protective equipment such as the ACH. However, despite the significance and broad impact of these protocols, DOT&E did not explicitly consult with heads of the Military Departments to provide them an opportunity to comment on new or changed test protocols and did not adequately document the adjudication of inputs provided by program offices and subject matter experts in the staffing process. The program office also did not solicit comments on the helmet test protocols with the helmet vendors and DCMA.

### Discussion

DoD Directive 5141.02, “Director of Operational Test and Evaluation (DOT&E),” states that DOT&E shall prescribe policies and procedures for the conduct of Live Fire Test and Evaluation (LFT&E) and delegate authority to approve LFT&E strategies. LFT&E strategies include PPE testing such as hard body armor, soft body armor, and helmets.

When DOT&E was developing the body armor test protocol, the National Academies Phase II report recommended that DOT&E conduct due diligence before formally adapting a statistically based body armor protocol. The National Academies Phase III report recommended that:

DOT&E should provide briefings to and receive feedback from all stakeholders in DoD (military service Program Executive Officers, testers, users) and non-DoD organizations (National Institute of Justice, National Institute of Standards and Technology, certified private testing laboratories, vendors) concerning the statistically based protocol. DOT&E should act on feedback from the community to improve the proposed protocol as necessary, to ensure that testing terms and concepts make sense to a nontechnical audience, and it should promote the use of the statistically based protocols in future national standards for body armor testing, as appropriate.

## ***DoD Leadership Involvement***

DOT&E stated that the helmet test standards are policies informed by a technical understanding of both the testing process and the capabilities of the item under test. They also provided drafts of the combat helmet FAT and LAT protocols to various stakeholders for comments. DOT&E sent the FAT protocol draft on August 17, 2010, and it underwent two additional review iterations.<sup>14</sup> DOT&E also sent the LAT protocol draft on February 25, 2011.<sup>15</sup> Subject matter experts within these organizations provided comments on the protocol drafts in areas such as test range set up, sample size, and ballistic impact locations and measurements.

Although we found records of subject matter expert involvement (including PEO Soldier), we found no coordinated input from DoD leadership, including heads of the Military Departments. There was no objective evidence that DoD leadership and heads of the Military Departments were given the opportunity to provide input to policies that establish an acceptable level of risk (that is, acceptable number of ballistic penetrations) to the ACH.

## ***Documenting Inputs***

PEO Soldier submitted nine nonconcurrences (four critical and five substantive) to DOT&E after reviewing the first draft of the combat helmet FAT protocol. PEO Soldier was concerned that a statistically based protocol that allows any percentage of the helmets to be penetrated on any shot during FAT could result in unintended consequences. PEO Soldier further recommended that the number of allowed penetrations be vetted before mandating the new protocol. DOT&E responded to these nonconcurrences by stating that “discussion will occur.” We found no evidence that DOT&E incorporated PEO Soldier’s input and/or held technical discussions with PEO Soldier personnel on its nonconcurrences. DOT&E also stated that there was no further action on these nonconcurrences and provided no official response to the nonconcurrences.<sup>16</sup>

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<sup>14</sup> Recipients of the FAT protocol drafts were departments within the Marine Corp Systems Command (MCSC), Naval Sea Systems Command (NAVSEA), Army Research Laboratory Survivability/Lethality Analysis Directorate (ARL/SLAD), PEO Soldier Program Manager Soldier Protective Equipment (PM SPE), Deputy Under Secretary of the Army Test and Evaluation Office (DUSA-TE), DLA Troop Support Clothing and Textile, ATEC, U.S. Special Operations Command (USSOCOM) and Institute for Defense Analysis (IDA).

<sup>15</sup> Recipients of the LAT protocol drafts were U.S. Army Acquisition Support Center (USAASC), U.S. Marine Corps (USMC), Developmental Testbed Center (DTC), PM SPE, DLA, U.S. Army Training and Doctrine Command (USA TRADOC), USSOCOM, U.S. Army Materiel Command (USA AMC), National Institute of Standards and Technology (NIST), IDA, Federal Bureau of Investigation (FBI) Academy, U.S. Air Force Acquisition (USAF SAF/AQRE), ARL/SLAD, ATEC, DUSA-TE, and Office of the Chief of Naval operations (OPNAV).

<sup>16</sup> During the course of our assessment, PEO Soldier stated that they were in agreement with the 90/90 standard on the basis that the legacy FAT RTP (0 penetrations out of 20 shots) equates to 89/90 when analyzed against the Clopper-Pearson method.

We also reviewed documents to determine the origin of the of the FAT RTP 90/90 standard and LAT RTP of 4 percent AQL, including reports and studies conducted by both the National Academies and ATEC on the hard body armor detailed in Finding A. DOT&E stated that in addition to the influence of the National Academies and ATEC studies on hard body armor, the RTP FAT and LAT requirements were recommended by NRC statisticians. DOT&E further stated that the National Institute of Justice (NIJ) also expressed that a 90/90 standard was high performing and a good protocol for any PPE. However, there were no documented records of the recommendations from the NIJ or the NRC, specifically for the helmet test protocols. DOT&E stated that recommendations were mostly informal and undocumented.

### ***Coordination with ACH Vendors***

Although the National Academies made the recommendation to receive vendor feedback for developing body armor test protocol, the same due diligence of receiving vendor feedback still applies to developing the helmet test protocol. However, vendors were not asked to review and provide input to the helmet protocols. Vendors have years of experience in design and manufacturing of helmets. Significant investment in research and development for increased performance, weight reduction, and cost saving have been performed by vendors, acquiring a depth of knowledge that could have been useful in developing the helmet protocols.

Another recommendation from the Phase III report states that any revision to the protocol should be evaluated to ensure that there is no detrimental impact on the quality and performance of an already successful product. The Phase III report specifically states:

In particular, because manufacturers have strong incentives to build armor that has a high chance of passing FAT and LAT, there is some chance that the change in test protocol could have unintended impacts on body armor design and/or performance. Given the success of the current body armor in the field, changes in testing protocols should be made with deliberate caution to ensure that plate performance is maintained (or improved) while also ensuring that the best science is brought to bear on testing body armor.

Similar to the body armor, the currently fielded ACHs have also performed well against their intended threats. ACH vendors also disclosed that they are capable of performing well above the RTP test protocol requirements.

## ***Role of the Program Manager***

The DOT&E helmet test protocols do not explicitly allow program managers to modify the stringency of the helmet test protocols. Program managers may need protocol modifications as they manage programmatic risks associated with the use of new manufacturing processes, materials, or design. DOT&E has expertise in testing but lacks the expertise in ACH design and hardware.

Program managers' limited authority over testing protocols of their products is in conflict with the requirements of DoDI 5000.02, "Operation of the Defense Acquisition System." DoD Instruction (I) 5000.02 defines the authority of the program manager as covering all design, manufacturing, test, and all other program life cycle processes. In addition, the testing protocols can limit the program manager's ability to use a balanced approach to manage programmatic risks such as the use of new manufacturing processes and the use of new materials or alternate designs. These changes may necessitate changes to the testing protocols, which the program manager does not control.

## ***DOT&E Assessment Discussion***

DOT&E committed to provide proposed protocols to the senior leadership of the affected Services for comment. The Director, DOT&E, will consider and resolve comments received.

DOT&E stated that they do not work directly with vendors; this is the purview of program offices. However, DOT&E has and will continue to encourage program offices to provide vendors the opportunity to submit through program offices any comments on proposed protocols.

Currently, DOT&E allows protocols to be changed and made more stringent, provided that program managers submit a well-justified request for approval. DOT&E will state that changes are permitted in future protocol updates, but DOT&E retains the authority to approve such changes.

## **Recommendations**

C.1. Due to the significance and broad impact of these protocols, we recommend that DOT&E ensure that affected organizations, including heads of the Military Departments, are consulted in developing the protocols and have an opportunity to provide input on new or changed test protocols. DOT&E should also ensure that inputs received are documented and adjudicated.

C.2. We recommend that PEO Soldier solicit input from helmet vendors and DCMA on new or changed test protocols. PEO Soldier should also ensure that inputs received are documented and adjudicated.

C.3. We recommend that DOT&E include an explicit statement in future protocol revisions that allows program managers to modify the test protocols, provided that program managers submit a well-justified request for approval.

## **DOT&E and PEO Soldier Comments**

DOT&E will ensure affected organizations, including heads of Military Departments, are consulted in developing new or changed protocols. Responses will be adjudicated by the DOT&E and documented. A request to both the Secretary of the Army and Secretary of the Navy to review the current protocol resulted in no recommendations for changes to the protocol by both Departments.

PEO Soldier will solicit feedback from our industry partners as well as DCMA prior to the implementation of any new testing protocol. Industry feedback together with feedback from many various engineers working for PEO Soldier will be reviewed and adjudicated. All adjudicated feedback will be provided to DOT&E for review and may warrant the continued modification of existing and future rest protocols and standards.

The next protocol revision will include an explicit statement that permits program managers to increase the test protocol stringency following approval by DOT&E of a well-justified request to do so.

## **DoD OIG Response**

DOT&E and PEO Soldier's comments were fully responsive, and no additional comments are required.

## Finding D

### Evaluation of Aggregate Test Results

The FAT RTP acceptance was based on an aggregate of all test outcomes under varying conditions to achieve 90/90, or 17 penetrations out of 240 shots. This could result in passing FAT, despite test results showing clusters of failures of a unique helmet size or in a particular test environment.

### Discussion

The helmet test protocol aggregates the FAT RTP test results across environmental conditions, helmet sizes, and shot locations and applies the Clopper-Pearson method. The Clopper-Pearson method employs binomial distribution in the calculation of bounds of the confidence interval. In general, the sum of binomial distributions do not yield a binomial distribution, unless the failure rates are the same for each individual environmental condition and helmet size. Because the failure rates are unknown for each individual environmental condition, we cannot assume that the aggregated test result represents a binomial distribution and therefore the test results cannot validate that the 90/90 standard has been met.

### ***Implications of Aggregating Test Results***

In a July 13, 2012 letter, DOT&E provided a response to Representative Slaughter's inquiry into the FAT test protocol. The DOT&E response stated that,

...the new protocol samples a large enough number of helmets for testing to demonstrate statistically significant differences in performance due to environmental conditions (such as hot and cold temperatures), among helmet sizes, and among different vendors' designs ...

A review of the DOT&E test data analysis methods identified that the results are aggregated across different environmental conditions, helmet sizes, and shot locations. Analyzing aggregated test data when determining whether the results pass or fail RTP FAT masks statistically significant differences in performance due to environmental conditions, helmet sizes, and different vendor designs.

The following scenarios illustrate the implications of aggregating test results using environmental conditions as the only variable, without introducing the other variables such as helmet sizes, shot locations, and vendor designs.

Scenario 1 demonstrates that individually, all of these conditions fail to meet a 90/90 standard. But if the individual results are combined and the Clopper-Pearson method is applied, the combined sample results meet the standard.

*Table 5. Scenario 1*

Conditions	Number of Shots	Number of Failures	LCL of P(nP)
Ambient	60	5	85%
Hot	60	4	87%
Cold	60	4	87%
Seawater	60	4	87%
<b>Total</b>	<b>240</b>	<b>17</b>	<b>90%</b>

Scenario 2 demonstrates the possibility of 17 failures during ambient conditions. The test results in ambient conditions fail to meet the standard, while the combined result of 17 failures out of 240 shot appears to meet the standard.

*Table 6. Scenario 2*

Conditions	Number of Shots	Number of Failures	LCL of P(nP)
Ambient	60	17	63%
Hot	60	0	96%
Cold	60	0	96%
Seawater	60	0	96%
<b>Total</b>	<b>240</b>	<b>17</b>	<b>90%</b>

In both the scenarios, the combined result of 17 failures out of 240 shots meet the 90/90 standard. This could result in passing FAT, despite test results showing failures in a particular test environment.

### ***DOT&E Assessment Discussion***

DOT&E was aware of these implications, and committed to perform additional statistical analysis beyond that specified in the protocol. With respect to aggregation of helmet test data, DOT&E will analyze whether significant clusters of inadequate performance exist. DOT&E will use either logistic regression analysis or two-sample tests of proportions to analyze the probability of no penetration for significant clusters. Significant results would

trigger additional testing to determine whether helmet protocol requirements were met by condition. DOT&E will issue a memorandum describing the technical details of this analysis and will subsequently incorporate this approach in a published update to the existing test protocol.

DOT&E and PEO Soldier will adopt this approach with the current lightweight ACH solicitation, but not as a published change to the test protocol specified in the current solicitation. Although the solicitation will not be changed, DOT&E will analyze the test results obtained under the current solicitation to see if significant differences (based on environment, helmet size, or shot location) exist, and if so, will conduct additional testing to determine the FAT RPT criteria under the test condition of interest. If the results demonstrate poor performance, DOT&E will not field the lightweight ACH design.

## Recommendations

D.1. We recommend that DOT&E and PEO Soldier describe the method of identifying and addressing statistically significant differences in performance due to environmental conditions, helmet sizes, shot locations, and different vendor designs for all FAT results under the DOT&E helmet test protocol.

D.2. We recommend that PEO Soldier and DLA consider the contractual implications of not fielding an ACH design that passes FAT yet shows significant clusters of inadequate performance.

## DOT&E and PEO Soldier Comments

DOT&E has developed procedures for identifying and addressing statistically significant differences in performance. DOT&E has asked the National Academies, as part of its review of the helmet test protocols, to comment on the adequacy of these procedures to identify significant differences in performance. DOT&E will incorporate these procedures (as revised based on feedback from the National Academies) in the next revision of the protocol. DOT&E has provided a copy of these procedures to the DoD OIG staff for information.

## DoD OIG Response

DOT&E and PEO Soldier's comments were fully responsive. We reviewed DOT&E's detailed procedures for identifying and addressing statistically significant differences in performance and have additional points for consideration. However, no additional comments from DOT&E and PEO Soldier are required.

The DOT&E strategy to identify significant differences and trends in performance is a statistical approach to determine or trigger whether additional testing is required. In addition to this approach, we recommend that PEO Soldier designate the triggering of a cluster analysis as a nonconformance, requiring further engineering evaluation and disposition. Failures under certain conditions can be attributed to design, manufacturing, material weaknesses, or test equipment/test conduct variability. The root cause of these failures and subsequent mitigation plans should be a product of an established failure analysis and corrective action process that involve the vendor, PEO Soldier's Quality Assurance representatives, and DCMA.

## Appendix A

### Scope and Methodology

We conducted this assessment from July 2012 through February 2013 in accordance with the Council of the Inspectors General on Integrity and Efficiency, "Quality Standards for Inspection and Evaluation." Those standards require that we plan and perform the assessment by obtaining sufficient and appropriate evidence to provide a reasonable basis for our conclusions. We believe that the evidence obtained provides a reasonable basis for our conclusions.

To assess the basis for the RTP requirements and determine whether the RTP requirements are appropriate for the ACH, the DoD OIG team assessed three different areas: ACH test protocols and standards, test processes, and production and procurement processes.

We conducted interviews with DOT&E, PEO Soldier, DLA, DCMA, ATEC, and ACH vendors. We wrote summaries after each meeting that were signed and agreed upon by attending organizations.

We conducted assessments at DOT&E and PEO Soldier to determine PEO Soldier's relationship with DOT&E and other organizations involved in the procurement of ACHs. We also analyzed information on the ACH contracting and procurement processes, requirements and specification, oversight at test and manufacturing facilities, and test implementation plans. Most importantly, we analyzed details of the legacy ACH test protocols, details of the DOT&E helmet test protocols, the rationale for its established requirements, and the organizations involved in its development.

We conducted the assessment at U.S. Army Test and Evaluation Center (ATEC) in Aberdeen, Maryland, which will be conducting future lightweight ACH testing. The objective of the assessment was to understand the ACH test processes and set-up, and to understand ATEC's input to the DOT&E helmet test protocols.

We also performed assessments at ACH vendor facilities. The objectives of the assessments were to understand the ACH manufacturing process and determine the impact of the new DOT&E test protocols to the vendors. We also verified to determine if vendors provided input to the DOT&E helmet test protocols.

### Use of Technical Assistance

The Quantitative Methods Division provided support and statistical expertise in the analysis of DOT&E's First Article Testing protocol. Specifically, QMD analyzed the Resistance to Penetration requirements and statistical method to determine acceptability of combat helmets.

## Appendix B

### Representative Slaughter's Letter to the DoD Office of Inspector General

**COMMITTEE ON RULES**

**RANKING MEMBER**

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WEBSITE: <http://www.louise.house.gov>

June 26, 2012

Honorable Lynne M. Halbrooks  
Acting Inspector General  
Department of Defense  
400 Army Navy Drive  
Arlington, VA 22202-4704

Dear Inspector General Halbrooks:

I write to you today to request that you review the Department of Defense's (DoD) current testing standards for Advanced Combat Helmets (ACHs).

Since 2006, I have worked extensively with the Department's Inspector General to ensure that our troops are equipped with the best available body armor. I know you share my belief that America's servicemen and women deserve the highest quality protective armor and equipment when they are in harm's way for our country. As the Department has learned from past experience, safe armor and equipment in the field starts with comprehensive and effective testing procedures at home.

Government employees and contractors have shared concerns with my office that a recent modification to the standard for ballistic testing for ACHs would allow up to 17 penetrations out of 240 test shots. The result of that standard is a 90% probability of no perforation with 90% confidence during first article testing. I am concerned that a standard that allows 17 penetrations puts contractors above the need to produce effective and consistent equipment for the men and women of the military.

While procurement standards have improved in recent years, the current standard poses an unacceptably high risk for equipment intended to protect American lives.

In 2010, the Department was forced to recall 44,000 ACHs after it was determined the helmets did not meet service standards due to questionable manufacturing processes. In the field, a penetration to a combat helmet could result in a fatality or extremely serious injury, which is why the Department should continue to take testing and performance concerns seriously.

Our goal should always be the most effective equipment possible and as such, I strongly urge you to review ballistics-testing procedures currently in place to ensure we are meeting this goal.

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Thank you for your continued commitment to the men and woman of our Armed Forces. I am confident that you have our troops' best interests in mind and will continue do your very best to improve the quality standards of all protective body armor and equipment. I have also enclosed a copy of a letter to Secretary Panetta for your review. I look forward to your response.

Sincerely,



Louise McIntosh Slaughter  
Member of Congress

Cc: Honorable Leon E. Panetta, Secretary of Defense

# Appendix C

## Clopper-Pearson Method

The Army Research Laboratory published a paper on March 2011 titled “A Comparison of Various Methods Used to Determine the Sample Size Requirements for Meeting a 90/90 Reliability Specification,” by David W. This paper explains the Clopper-Pearson Method as follows:

### 2.1 The Clopper-Pearson Method

The Clopper-Pearson (1934) method for binomial confidence intervals is popular for its relative ease to calculate. In general, the confidence interval limits,  $(L_{CP}, U_{CP})$ , are solutions to the

$$\text{statements } \sum_{i=X}^N \binom{N}{i} L_{CP}^i (1-L_{CP})^{N-i} = \frac{\alpha}{2} \text{ and } \sum_{i=0}^X \binom{N}{i} U_{CP}^i (1-U_{CP})^{N-i} = \frac{\alpha}{2}.$$

If at least one success and one failure are observed among the samples, both endpoints of the interval can be expressed as functions of percentiles from  $F$  distributions. For an LCB, with  $X = N$ , the calculation simply reduces to  $L_{CP} = \sqrt[4]{\alpha}$ . Clopper-Pearson intervals are often referred to as “exact” intervals since they are derived from exact probability statements and not any distributional approximations. As such, the Clopper-Pearson is often touted in introductory statistics textbooks.

To satisfy the 90/90 reliability specification using the Clopper-Pearson method, we seek the minimum value of  $N$  which satisfies  $.90 \leq .10^{\frac{1}{N}}$ . Taking the logarithm of both sides of this inequality, we have  $\ln(.90) \leq \frac{\ln(.10)}{N}$  which leads to the solution  $N \geq \ln(.1)/\ln(.9) = 21.85$ .

Since  $N$  must be an integer, the number of zero-failure trials required to meet the 90/90 specification under the Clopper-Pearson method is rounded up to 22.

## Appendix D

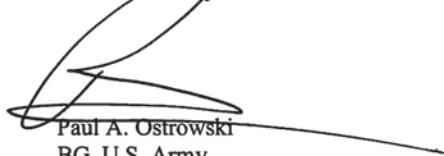
### Notice of Concern and Notice of Concern Resolution

DEC 07 2012

MEMORANDUM FOR DEPARTMENT OF DEFENSE (DoD) INSPECTOR GENERAL (IG)

SUBJECT: Advanced Combat Helmet (ACH) Technical Assessment (Project No. D2012-DT0TAD-007) Memorandum for Record

DOT&E and Program Executive Office (PEO) Soldier concur with the attached Memorandum of Record that describes the topics discussed during the November 14, 2012 meeting between the DoD IG ACH Technical Assessment Team, DOT&E, and PEO Soldier. DOT&E and PEO Soldier also acknowledge that the issues identified in the Notice of Concern are satisfactorily resolved.



Paul A. Ostrowski  
BG, U.S. Army  
PEO Soldier



J. Michael Gilmore  
Director  
Operational Test & Evaluation

Attachment:  
As stated



**INSPECTOR GENERAL**  
DEPARTMENT OF DEFENSE  
4800 MARK CENTER DRIVE  
ALEXANDRIA, VIRGINIA 22350-1500

DEC 05 2012

**MEMORANDUM FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION  
U.S. ARMY PROGRAM EXECUTIVE OFFICE, SOLDIER**

**SUBJECT:** Advanced Combat Helmet (ACH) Technical Assessment  
(Project No. D2012- DT0TAD-0007)

The attached Memorandum for Record (TAB A) describes the topics discussed during our meeting held on November 14, 2012, to discuss issues identified in the attached Notice of Concern - Advanced Combat Helmet Technical Assessment (TAB B). Please respond with your concurrence with the documented Memorandum for Record and acknowledge that the issues identified in the Notice of Concern have been satisfactorily resolved.

If you have any questions, please contact me or Ms. Anna Ferre at 703-604-8931.

A handwritten signature in black ink, appearing to read "R.R. Stone".

Randolph R. Stone  
Deputy Inspector General  
Policy and Oversight

**Attachments:**  
As stated



**DOD Office of the Inspector General  
TAD  
Memorandum for Record**



**Project Title:** Advanced Combat Helmet (ACH) Technical Assessment

**Project Number:** D2012-DT0TAD-0007.000      **MFR Author:** Anna Ferre

**Location:** Pentagon 3E1088      **Date:** Wednesday, November 14, 2012

**Purpose**

Continued discussion on the helmet protocols.

**Attendees**

As Stated Below

**Action Items/Documents Requested**

**Documents Obtained**

**Discussion**

Members from the Department of Defense Office of the Inspector General (DoD IG); Office of the Director, Operational Test and Evaluation (DOT&E); and the Army's Program Executive Office (PEO), Soldier, met on November 14, 2012, to discuss the DoD IG team's issues developed during their technical assessment of the testing of the Advanced Combat Helmet (ACH). Representing DOT&E was the Honorable Dr. J. Michael Gilmore, Director, OT&E; representing the DoD IG was Mr. Randolph Stone, Deputy Inspector General for Policy and Oversight; and representing PEO Soldier was BG Paul Ostrowski. Also attending were Mr. Richard Sayre and Mr. Chris Moosmann from DOT&E; Mr. Al Dopita, Ms. Anna Ferre, and Mr. Andrew Fecchelm from the DoD IG; and LTC Frank Lozano from PEO Soldier. The attendees addressed the following topics:

**DOT&E Authority**

The DoD IG requested further clarification of DOT&E's authority to set policies pertaining to personnel protective equipment (PPE) test standards and the process for which test protocols are formally coordinated and staffed through the user community's policy makers. The DoD IG wanted to know how DOT&E ensures that the Services have an opportunity to provide input to PPE policies. More specifically, the DoD IG was concerned that input by the Service's leadership was not apparent.

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DOT&E stated that they have the authority to set policies pertaining to PPE test standards in accordance with the authorities given to the Director by statute. DOT&E explained that test standards are a policy issue formed by a technical understanding of both the testing process and the capabilities of the item under test. PPE testing must be sufficiently rigorous and based on appropriate statistical principals to draw valid conclusions about performance with reasonable confidence. The lack of formal requirements documents for PPE (hard armor, helmets, and soft armor) led DOT&E to publish the protocols to establish common testing and performance standards for these items as items overseen by DOT&E in accordance with section 2366, title 10, United States Code (10 U.S.C. 2366). DOT&E solicits input from the user community (including program offices, test agencies, combat developers, and non-DoD agencies such as the FBI and NIST) with regard to PPE test protocols.

The Director, OT&E, stated he will provide proposed protocols to the senior leadership of the affected Service(s) for comment. Input received will be considered and adjudicated by the Director. The DoD IG agreed that providing proposed protocols for review at the senior leadership level would help ensure visibility of the protocols within the Services.

#### **DoD IG Issues Developed During the Technical Assessment**

The DoD IG acknowledged that the new helmet protocols are an improvement from legacy helmet test protocols with regard to increased sample size and statistical integrity. While the legacy First Article Test (FAT) protocols tested 4 helmets, the new protocol tests 48 helmets and provide data that demonstrate differences in performance due to environmental conditions, helmet sizes, and different vendor designs. However, the DoD IG identified four issues as a result of documentation and information provided by DOT&E and PEO Soldier.

The DoD IG team summarized the issues as:

- Lack of helmet performance characterization for the ACH protocol before it was approved.
- DOT&E's apparent desire to standardize statistical performance measures across PPE.
- Lack of a specific policy to allow test protocol modification by Service technical design authorities.
- The statistical implications of aggregating test results across environmental conditions, shot locations, and helmet sizes.

#### Helmet Performance Characterization

The DoD IG referenced a 2010 U.S. Army Test and Evaluation Center (ATEC) study that characterized the body armor ballistic performance and recommended to DOT&E a sample size and ballistic performance parameters for the test protocols (90% probability of no penetration [P(nP)] with 90% confidence level, and 4% Acceptable Quality Level.) The DoD IG was concerned that a characterization study was not conducted for combat helmets prior to the release of the new helmet test

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protocols.

DOT&E and PEO Soldier committed to fully characterize the performance of the ACH helmets. DOT&E also indicated that it, along with the Marine Corps, will characterize the performance of the Enhanced Combat Helmet (ECH) once the ECH design is stable. DOT&E will provide the details of the plans to characterize the helmets to the DoD IG team when the respective plans are approved by DOT&E.

Standardization of Protocols Across PPE

The DoD IG stated that there are potential issues with DOT&E's plans to standardize test protocols across all PPE categories (hard armor, soft armor, and helmet). The DoD IG asked if a standard test protocol across all PPE categories is appropriate given their differences in material and manufacturing processes.

DOT&E considers the established test standards for hard body armor plates and helmets that reflect a common metric to have elements that are generally applicable to all PPE. Specifically, the standards for PPE testing must be as statistically principled and rigorous as the extant standards for helmets and hard body armor plates. DOT&E acknowledged that the performance metrics incorporated in test standards used for PPE should be empirically based on the data generated by characterization studies conducted on the individual elements of PPE using the appropriate threats. DOT&E stated that deviation from what is commonly termed a "90/90 performance metric" could be appropriate, based on the performance revealed by these characterization studies against the specified threats. Therefore, the DoDIG team understood that DOT&E's efforts to establish standardized protocols does not necessarily mean the same exact performance metrics will be incorporated in the testing protocols used for all categories of PPE; rather, those metrics will be standardized by PPE category, as appropriate.

Protocol Modification

The DoD IG also cited issues with the technical design authority's ability to set test requirements above the current test protocols. The current helmet protocols do not explicitly allow for program managers to set more stringent test requirements. If DOT&E continues with plans to standardize test protocols across all PPEs, program managers are not able to implement more stringent testing standards as appropriate.

In current practice, DOT&E allows protocols to be changed and, in particular, made more stringent, provided program managers submit to DOT&E for approval a request that is well-justified. This policy, that changes to protocols are possible but DOT&E retains the authority to approve such changes, will be described explicitly in protocol updates and future protocols.

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Aggregation of Test Results

The last issue pertains to the aggregation of test results across environmental conditions, shot locations, and helmet sizes. Using this evaluation method, it is possible that a helmet may fail individually for ambient, hot, cold, or seawater test conditions, yet pass if the test results are aggregated and calculated using the Clopper-Pearson method.

DOT&E agreed and stated that additional statistical analysis will be conducted beyond that specified in the protocol. With respect to aggregation of helmet test data, DOT&E will analyze whether significant clusters of inadequate performance exist in both the backface deformation and the penetration data. For backface deformation, DOT&E will use regression analysis to test for significant differences. If the results are significant, then deformation will be reported separately by condition using the regression model. Failures would trigger additional testing, sufficient to determine the 90/90 criteria under the test condition(s) of interest. DOT&E will use either logistic regression analysis or two-sample tests of proportions to analyze the probability of no perforation for significant clusters. Again, significant results would trigger additional testing to determine whether helmet protocol requirements were met by condition. DOT&E will issue a memorandum describing the technical details of this analysis and will subsequently incorporate this approach in a formal update to the existing test protocol.

DOT&E indicated that DOT&E and PEO Soldier will adopt this approach with the current lightweight ACH solicitation, but not as a formal change to the test protocol specified in the current solicitation. Although the solicitation will not be changed, DOT&E will analyze the test results obtained under the current solicitation to see if significant differences (based on environment, helmet size, or shot location) exist, and if so, conduct additional testing to then determine the 90/90 criteria under the test condition of interest. If, following that additional testing, the results demonstrated poor performance, the lightweight ACH design will not be fielded. The DoD IG team indicated this approach resolved the issues identified in the Notice of Concern and did not express any need to revise the ACH solicitation as discussed in DOT&E's October 12, 2012, response to the DoDIG team's Notice of Concern.

**Further Review**

DOT&E has contracted with the National Research Council (NRC) to conduct an external review of helmet test protocols to evaluate the adequacy of the current helmet test protocols and procedures. The NRC has appointed a panel of distinguished scientists, statisticians, and subject matter experts to accomplish this review. DOT&E will inform the panel on all of the previously discussed issues and invite the DoD IG team to participate in the panel's public data gathering sessions. The work of the NRC will be used by DOT&E to make further changes to the existing test protocols and procedures for combat helmets, as appropriate. DOT&E will inform the DoD IG of all of the NRC's findings and any associated changes to the helmet test protocols and procedures.

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**Attachments**

**Associated Documents**

Attending Party Review Not Required (As determined by TAD PM or Supervisor)

**Attending Party Review**

I agree with the summary of this meeting.  Yes  No

\_\_\_\_\_  
Signature/Date

**MFR Approved:**

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TAD PM or Supervisor Signature/Date

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INSPECTOR GENERAL  
DEPARTMENT OF DEFENSE  
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ALEXANDRIA, VIRGINIA 22350-1500

SEP 12 2012

MEMORANDUM FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION  
PROGRAM EXECUTIVE OFFICE SOLDIER

SUBJECT: Notice of Concern—Advanced Combat Helmet Technical Assessment  
(Project No. D2012-DT0TAD-0007)

- References:
- (a) DOT&E Memorandum, "Standardization of Combat Helmet Testing," September 20, 2011
  - (b) DOT&E Memorandum, "Standard for Lot Acceptance Ballistic Testing of Military Combat Helmets," May 4, 2012
  - (c) PEO Soldier Study, "Advanced Combat Helmet (ACH) Resistance to Penetration Analysis," July 31, 2012

We are issuing this Notice of Concern to inform you that the Department of Defense, Inspector General (DoD IG) team identified two issues that require your attention. During meetings held with your office and Office of the Director, Operational Test and Evaluation (DOT&E) at Fort Belvoir, Virginia, from August 27 to 29, 2012, your team provided information that indicates that the historical Advanced Combat Helmet (ACH) ballistic performance is significantly higher than the standards defined in References (a) and (b).

During our meetings, we received Reference (c), which details historical ACH test data from the past 5 years. Your office summarized that when the Clopper-Pearson Method is applied to the aggregate test data, the ACH Probability of No Penetration  $P(nP)$  is 99% with a 99% Lower Confidence Level. Furthermore, you concluded that "Currently fielded ACH far exceeds DOT&E's statistical requirement of a 90% Probability of no Penetration with a 90% Lower Confidence Level when assessed against the 9mm threat."

The Acceptable Quality Level (AQL) detailed in Reference (b) is another area of concern. The DOT&E-mandated 4% AQL (4 ballistic defects per 100 helmets) for lot acceptance test lowers performance expectations because past ACH lot acceptance test standards allow for zero ballistic defects.

Our concern is that the lightweight ACH solicitation, scheduled to be awarded during the first quarter of fiscal year 2013, will set a ballistic performance expectation that is significantly lower than historical capabilities. This contract award will be the first ACH contract to include DOT&E's ACH test protocols defining a  $P(nP)$  of at least 90% and an AQL of 4%.

The DoD IG team's overall conclusion is that mandating ballistic performance expectations that are significantly lower than historical capabilities may lead to a reduction in future ACH helmet performance. We recommend that PEO Soldier coordinate with the Defense Logistics Agency (DLA) to assess the upcoming solicitation to ensure that there is no reduction in helmet performance. We also recommend that DOT&E coordinate with PEO Soldier to ensure that the historical test data are taken into account in the test protocol so that future helmet procurements meet or exceed historical capabilities. Finally, we recommend that DOT&E, PEO

Soldier, and DLA work together to review the proposal data and verify that ACH ballistic quality is not reduced.

Please provide comments that state whether you agree or disagree with the issue and recommendation. If you agree, describe what actions you have taken or plan to take to address the concerns and include the completion dates of your actions. If you disagree, please give specific reasons why you disagree and propose alternative action if appropriate. Once we complete our full assessment, we will provide a report on our findings, along with any additional matters that might come to our attention.

We should receive your comments by October 12, 2012. We normally include copies of the comments in the report. If you consider any matters to be exempt from public release, you should mark them clearly for Inspector General consideration.

If possible, send a Microsoft Word (.doc) file and a portable document format (.pdf) file containing your comments to [anna.ferre@dodig.mil](mailto:anna.ferre@dodig.mil). Copies of your comments must have the actual signature of the authorizing official for your organization. We are unable to accept the /Signed/ symbol in place of the actual signature.

We appreciate the courtesies extended to the staff. Please direct questions to Ms. Anna Ferre at (703) 604-8931.



Randolph R. Stone  
Deputy Inspector General  
Policy and Oversight

cc:  
Defense Logistics Agency

## Appendix E

### Office of the Director, Operational Test and Evaluation and Program Executive Office Soldier Comments

APR 19 2013

MEMORANDUM FOR DEPARTMENT OF DEFENSE (DoD) INSPECTOR GENERAL (IG)

SUBJECT: Director, Operational Test and Evaluation and Program Executive Officer Soldier  
Comments on DoD IG Report: Advanced Combat Helmet (ACH) Technical  
Assessment

Reference: DoD IG Memorandum, "Advanced Combat Helmet Technical Assessment  
(Project No. D2012-DT0TAD-0007.000)," April 1, 2013

DOT&E and Program Executive Office (PEO) Soldier have reviewed the referenced report and agree with the findings and recommendations. This response provides our comments on the recommendations.

#### **Recommendation for Finding A (Origin of Resistance to Penetration)**

**Requirements:** Recommendation that DOT&E and PEO Soldier fully characterize the performance of all helmet designs included in the combat helmet test protocols. Performance characterization should consider threat, historical test data, prototype test data, and manufacturing capabilities. Based on helmet performance characterizations, DOT&E and PEO Soldier should determine if modification to the FAT and LAT protocols are appropriate.

Comment: Characterization of fielded ACH will rely on historical test data since the Army does not intend to buy additional ACH designs. We will conduct additional testing to characterize helmets not currently fielded, such as the Lightweight ACH, the Enhanced Combat Helmet (ECH), and the Soldier Protective System Integrated Head Protection System (SPS IHPS). This characterization will be based on a risk assessment that identifies and documents the testing that provides the most important data, since it is unrealistic to scope a characterization effort that includes every desirable test. Based on the characterization data, DOT&E will determine whether FAT and LAT protocols should be modified.

#### **Recommendation for Finding B (Acceptable Quality Level Based on Safety)**

**Criticality:** Recommendation that in addition to considerations made to Government risk, manufacturer risk, and historical LAT data, DOT&E should also consider the safety criticality of the helmet in establishing the AQL requirement for LAT RTP in future protocol revisions.

Comment: DOT&E will consider helmet safety criticality as an additional consideration in establishing the AQL requirement for LAT RTP during the next protocol revision. The next protocol revision will consider recommendations from the on-going National Academies review of helmet test protocols. This study should be complete by December 2013.

#### **Recommendation for Finding C (Coordination of Helmet Test Protocols):**

Recommendation that DOT&E ensure the affected organizations, including heads of the Military Departments, are consulted in developing the protocols and have an opportunity to provide input on new or changed test protocols. DOT&E should also ensure that inputs received are documented and adjudicated.

Comment: DOT&E will ensure affected organizations, including heads of Military Departments, are consulted in developing new or changed protocols. Responses will be adjudicated by the DOT&E and documented. A request to both the Secretary of the Army and Secretary of the Navy to review the current protocol resulted in no recommendations for changes to the protocol by both Departments.

Recommendation that PEO Soldier solicit input from helmet manufacturers and DCMA on new or changed test protocols. PEO Soldier should also ensure that inputs received are documented and adjudicated.

Comment: PEO Soldier will solicit feedback from our industry partners as well as DCMA prior to the implementation of any new testing protocol. Industry feedback together with feedback from many various engineers working for PEO Soldier will be reviewed and adjudicated. All adjudicated feedback will be provided to DOT&E for review and may warrant the continued modification of existing and future test protocols and standards.

Recommendation that DOT&E include an explicit statement in future protocol revisions that allows program managers to modify the test protocols, provided that program managers submit a well-justified request for approval.

Comment: The next protocol revision will include an explicit statement that permits program managers to increase the test protocol stringency following approval by DOT&E of a well-justified request to do so.

**Recommendation for Finding D (Evaluation of Aggregate Test Results):**

Recommendation that DOT&E and PEO Soldier describe the method of identifying and addressing statistically significant differences in performance due to environmental conditions, helmet sizes, shot locations, and different vendor designs for all FAT results under the DOT&E helmet test protocol.

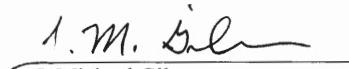
Comment: DOT&E has developed procedures for identifying and addressing statistically significant differences in performance. DOT&E has asked the National Academies, as part of its review of the helmet test protocols, to comment on the adequacy of these procedures to identify significant differences in performance. DOT&E will incorporate these procedures (as revised based on any feedback from the National Academies) in the next revision of the protocol. DOT&E has provided a copy of these procedures to the DoD IG staff for information.

Recommendation that PEO Soldier and DLA consider the contractual implications of not fielding an ACH design that passes FAT yet shows significant clusters of inadequate performance.

Comment: PEO Soldier is working with DLA to develop a risk mitigation plan to limit contractual implications of procuring ACHs that pass FAT but show clusters of inadequate performance. To date, based on historical ACH test performance, there is nothing to lead the Product Management Office to believe that this issue would occur; nevertheless, PEO Soldier will implement risk reduction measures to ensure clustering analysis is adequately performed and only helmets meeting the entire ballistic performance requirement are fielded.



Paul A. Ostrowski  
Brigadier General, USA  
Program Executive Officer Soldier



J. Michael Gilmore  
Director  
Operational Test & Evaluation

## ***Acronyms and Abbreviations***

<b>ACH</b>	Advanced Combat Helmet
<b>ADM</b>	Acquisition Decision Memorandum
<b>ANSI</b>	American National Standards Institute
<b>AQL</b>	Acceptable Quality Level
<b>ASQ</b>	American Society for Quality
<b>ATEC</b>	Army Test and Evaluation Center
<b>DCMA</b>	Defense Contract Management Agency
<b>DLA TS</b>	Defense Logistics Agency Troop Support
<b>DOT&amp;E</b>	Office of the Director, Operational Test and Evaluation
<b>ECH</b>	Enhanced Combat Helmet
<b>FAT</b>	First Article Testing
<b>FMJ RN</b>	Full Metal Jacket Round Nose
<b>OIG</b>	Office of Inspector General
<b>LAT</b>	Lot Acceptance Testing
<b>LCL</b>	Lower Confidence Level
<b>LFT&amp;E</b>	Live Fire Test and Evaluation
<b>LWH</b>	Lightweight Helmet
<b>NOC</b>	Notice of Concern
<b>ORD</b>	Operational Requirements Document
<b>PASGT</b>	Personnel Armor System, Ground Troops
<b>PEO</b>	Program Executive Office
<b>PM/SPE</b>	Product Manager, Soldier Protective Equipment
<b>P(nP)</b>	Probability of No Penetration
<b>PPE</b>	Personnel Protective Equipment
<b>RTP</b>	Resistance to Penetration



# **Whistleblower Protection**

## **U.S. DEPARTMENT OF DEFENSE**

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